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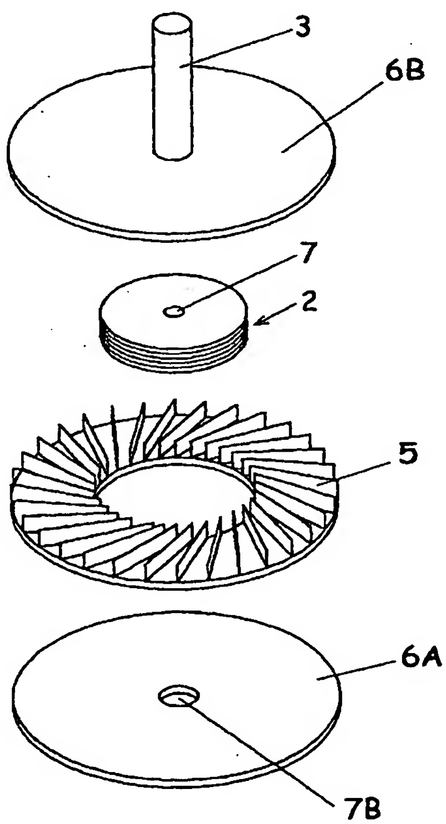
(54) Title: TURBINE, POWER GENERATION SYSTEM THEREFOR AND METHOD OF POWER GENERATION



(57) Abstract: A turbine includes a rotor (2) rotatable within a rotor chamber including a plurality of blades (5) about its periphery. Drag surfaces are created by the plurality of disc surfaces in the rotor (2), five discs being shown, and these receive a working fluid which is caused to flow spirally towards a central aperture (7) in the rotor (2). The working fluid may be provided at hypersonic or lower speeds and may be provided by a fuel burning means. A thermoelectric generator utilising the turbine is also disclosed.

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Turbine, Power Generation System Therefor and Method of Power Generation

Technical Field

This invention relates to a method and apparatus for power generation using a turbine to convert enthalpy of a working fluid to kinetic power. More particularly, but not exclusively, the present invention relates to a turbine structure and a method and apparatus for use in conjunction with a refrigeration cycle and preferably to power generation from an air conditioning cycle.

The term "fluid" or "working fluid" is used throughout the specification including the claims to relate to any suitable fluid but preferably, unless the context indicates otherwise, to a gaseous or vaporised fluid.

Background Art

Referring to Figure 1, in a conventional refrigeration cycle hot, high pressure refrigerant liquid enters a throttling device, often referred to as a Tx valve, which reduces its pressure and temperature at constant enthalpy. The drop in pressure causes the liquid to expand, flash to vapour and acquire heat. The heat absorbing vapour is passed through a heat exchanger or "evaporator " which absorbs heat from ambient temperature air blown across its surfaces by a fan, cooling the air and thereby providing the refrigeration effect. The ambient air passes through a fine fin structure surrounding the inner tubing of the heat exchanger. The temperature and enthalpy of the working fluid vapour is thus progressively increased as heat is added.

The heat laden working fluid vapour is then passed into an accumulator which has an internal structure designed to allow any remaining liquid to boil off prior to entering the compressor.

The energy rich warm working fluid vapour enters a compressor, which as a result of a work input, compresses the vapour thus raising its temperature and pressure.

A significant portion of the work input into the compressor re-appears as the heat of compression thus superheating the working fluid vapour.

The superheated working fluid vapour thus has its temperature elevated above that of the ambient temperature of the environment and enters a condenser, which has a structure similar to that of the evaporator. A heat exchange then occurs between the superheated working fluid vapour and the environment which is at a lower temperature. The heat exchange continues until sufficient heat is removed from the working fluid to cause a change of state from hot vapour to hot liquid.

The hot working fluid liquid enters a reservoir, usually referred to as a "receiver" which has a sufficiently large volume to support the requirements of the thermodynamic cycle and withstand the high pressure in the discharge line of the compressor. The hot high pressure refrigerant liquid then enters the Tx valve to complete the thermodynamic cycle.

A challenge in any typical generator that converts thermal energy to kinetic power is to maximise the efficiency of energy transformation. With energy becoming increasingly valuable, methods of energy conservation and reuse are being given increased attention. For example the numerous cogeneration processing plants evidence this energy awareness.

However the present invention in contrast provides the conversion of enthalpy to kinetic power, not heat.

It is thus an object of the present invention to provide a turbine, power generation system therefor and method of power generation that provides increased utilisation of available thermal energy, or at least one that provides the public with a useful alternative.

Further objects of the present invention may become apparent from the following description.

Preferably, one end of said at least one central aperture is closed and said fluid receiving means receives fluid from the open end of said at least one aperture.

Preferably, said fluid receiving means is a fluid channel feeding towards the periphery of a second rotor mounted coaxially with said first rotor within said rotor chamber.

Preferably, said fluid channel includes a fluid stop extending across said fluid receiving means, thereby forcing fluid to move radially outward from said central axis of rotation.

Preferably, said second rotor includes at least two drag plates about at least one centrally located aperture feeding into a further fluid receiving means.

Preferably, said second rotor includes a plurality of blades located about its periphery to receive fluid from said fluid channel.

Preferably, said further receiving means operates at a third pressure lower than said second pressure.

According to another aspect of the present invention, there is provided a turbine system including a turbine as defined in any one of the fifteen immediately preceding paragraphs, wherein the rotor chamber contains a plurality of said rotors mounted coaxially, wherein each rotor is separated from its adjacent rotor or rotors by a fluid stop extending across the at least one aperture, said fluid stop defining part of a fluid channel, which in use directs fluid from the at least one aperture of one rotor to a peripheral portion of an adjacent rotor.

According to a further aspect of the present invention, there is provided an electric generator including a rotor chamber, a rotor rotatable about a central axis within said rotor chamber and including a plurality of blades located about its periphery, at least one aperture located centrally of said rotor and extending through said rotor generally along or parallel to said central axis and at least two drag surfaces between said at least one aperture and said blades, said drag surfaces located relative to each other to in use create a drag force on fluid, (as herein defined), flowing between them, the electric generator further including at least one nozzle for communicating fluid at a first pressure

onto said blades, fluid receiving means operable at a second pressure lower than the first, the fluid receiving means adapted to receive fluid from said at least one aperture, and conversion means for converting kinetic energy embodied in rotation of said rotor to electric potential, wherein said rotor is adapted to in use receive fluid from said nozzle and direct the fluid to between said drag surfaces so that the fluid spirals inwardly towards said at least one aperture.

Preferably, said at least one nozzle is adapted to communicate fluid through its exit at the local sonic velocity.

Preferably, the exit of said nozzle is located within approximately 0.5mm from the leading edge of said blades.

Preferably in one embodiment a plurality of nozzles may be provided at different heights.

Preferably, one end of said at least one central aperture is closed and said fluid receiving means receives fluid from the open end of said at least one aperture.

Preferably, said fluid receiving means is a fluid channel feeding towards the periphery of a second turbine.

Preferably, said fluid channel includes a fluid stop extending across said fluid receiving means, thereby forcing fluid to move radially outward from said central axis of rotation.

Preferably, said second turbine includes at least two drag plates about at least one centrally located aperture feeding into a further fluid receiving means.

Preferably, said second turbine includes a plurality of blades located about its periphery to receive fluid from said fluid channel.

Preferably, said further receiving means operates at a third pressure lower than said second pressure.

According to a further aspect of the present invention, there is provided an electric generator including a turbine as defined in any one of the eleven immediately preceding paragraphs including a plurality of rotors mounted coaxially within said rotor chamber

and conversion means to convert rotation of said plurality of rotors to electric potential, wherein each turbine is separated from its adjacent turbine or turbines by a fluid stop extending across the at least one aperture, said fluid stop defining part of a fluid channel which in use directs fluid from the at least one aperture of one turbine to a peripheral portion of an adjacent turbine.

According to a further aspect of the present invention, there is provided a thermodynamic cycle for producing electric potential including the electric generator as defined in any one of the twelve immediately preceding paragraphs, a fluid cycle for supplying fluid to the at least one nozzle of said electric generator and for receiving fluid from a fluid output of said electric generator and including means to increase the enthalpy of said fluid from said output of said electric generator for supply to said at least one nozzle.

Preferably, a compressor is included in said fluid cycle, wherein said electric generator is located in the cycle with the fluid output feeding the input of the compressor.

Preferably, said compressor is at least partially powered by photovoltaic cells, wherein said photovoltaic cells are cooled by fluid at within the fluid cycle.

Preferably, the cycle further includes a thermoelectric generator fed by parts of the cycle having a temperature differential.

Preferably, cycle further includes a throttling device upstream of said electric generator.

Preferably, said compressor is at least partially powered by fuel cell and heat from said fuel cell is used to heat fluid in the fluid cycle.

Preferably, the cycle further includes a control system to control operation of said at least one nozzle between subsonic and sonic, or hypersonic, operation at the nozzle's exit.

According to a still further aspect of the present invention, there is provided a method of generating electric potential including

- providing a rotor within a rotor chamber, the rotor rotatable about a central axis within said rotor chamber and including a plurality of blades located about its periphery, at least one aperture located centrally of said rotor and extending through said rotor generally along or parallel to said central axis and at least two drag surfaces between said at least one aperture and said blades, said drag surfaces located relative to each other to in use create a drag force on fluid, (as herein defined), flowing between them;

- communicating a fluid at a first pressure onto said blades and direct the fluid between said drag surfaces so that the fluid spirals inwardly towards said at least one aperture;

- receiving fluid at a second pressure lower than the first from said at least one aperture; and

- converting kinetic energy embodied in rotation of said rotor to electric potential.

Preferably, the method further includes communicating said fluid onto said blades through a nozzle, wherein the fluid through the nozzle's exit is travelling at the local sonic or hypersonic velocity.

According to another aspect of the present invention, there is provided an electric generator including:

- a rotor chamber;

- a rotor rotatable about a central axis within said rotor chamber and including a plurality of blades located about its periphery and at least one aperture located centrally of said rotor and extending through said rotor generally along or parallel to said central axis;

- at least one nozzle for communicating fluid from said fluid supply means at a first pressure onto said blades, the nozzle adapted to provide fluid from its exit at or above the local sonic velocity;

- fluid receiving means operable at a second pressure lower than the first, the fluid receiving means adapted to receive fluid from said at least one aperture;

- conversion means for converting kinetic energy embodied in rotation of said rotor to electric potential;

wherein said rotor is adapted to in use receive fluid from said nozzle, thereby causing rotational force to be applied to the rotor about said central axis.

Preferably, the nozzle exit is located within approximately 0.5 mm from a leading edge of said blades.

Preferably, further includes at least two drag surfaces between said at least one aperture and said blades, said drag surfaces located relative to each other to in use create a drag force on fluid (as herein defined), flowing between them.

According to another aspect of the present invention, there is provided a thermoelectric generator including first fluid communication channel including a first substantially spherical enlargement and a second fluid communication channel including a second substantially spherical enlargement of larger diameter than the first, wherein said first and second substantially spherical enlargements are substantially coaxial and wherein the generator includes thermocouple means provided about the periphery of the first spherical enlargement, which in use provides electric potential output when a temperature differential exists between fluid in said firs and second fluid communication channels.

Preferably, the thermocouple means is silicon junction applied using thin film techniques.

Preferably, the thermoelectric generator may be part of the thermodynamic cycle described in the preceding paragraphs.

According to another aspect of the present invention, there is provided a turbine substantially as herein described with reference to Figures 5 to 7 and 10.

According to another aspect of the present invention, there is provided an electric generator substantially as herein described with reference to any of Figures 2 to 12.

According to another aspect of the present invention, there is provided a thermodynamic cycle for producing electric potential substantially as herein described with reference to Figures 2 to 12.

Further aspects of the present invention, which should be considered in all its novel aspects, may become apparent from the following description, given by way of example only and with reference to the accompanying drawings.

Brief Description of Drawings

Figure 1: Shows a schematic representation of a prior art refrigeration cycle.

Figure 2: Shows a schematic representation of the refrigeration cycle of Figure 1 further including a turbine to extract mechanical work.

Figure 3: Shows a schematic representation of a first alternative refrigeration cycle including a thermoelectric generator.

Figure 4: Shows a schematic representation of a second alternative refrigeration cycle including photovoltaic energy generation.

Figure 5: Shows an exploded view of a single stage turbine according to one embodiment of the present invention.

Figure 6: Shows a side view of the assembled single stage turbine of Figure 5 and the housing therefor.

Figure 7: Shows a top view of the assembled single stage turbine housing of Figure 5 showing the nozzle.

Figure 8: Shows a schematic representation of an electronically controlled nozzle for supplying fluid to a turbine according to the present invention.

Figure 9: Shows a portion of a cooled photovoltaic array for supplying energy to a compressor of a thermodynamic cycle.

Figure 10: Shows a schematic representation of a three-stage turbine according to one embodiment of the present invention.

Figure 11: Shows very diagrammatically a thermoelectric generator according to a possible embodiment of the present invention.

Figure 12: Shows very diagrammatically a cross sectional view of a possible arrangement of thermoelectric devices in a thermoelectric generator of one possible embodiment of the invention.

Modes for Carrying Out the Invention

The present invention may have application in an air conditioning cycle which may be to increase the efficiency of a refrigeration cycle by recovering a portion of the energy used to compress the fluid together with the heat acquired by the evaporator. Alternatively energy may be added to a fluid in order to generate additional power.

The generation of power from a basic vapour compression air conditioning cycle relies upon a translation of working fluid enthalpy to kinetic power. This may preferably take place between the evaporator output and the compressor input where heat acquisition is complete, enthalpy is almost at its maximum and temperature and pressure are at a minimum. A schematic representation of such a thermodynamic cycle including, in order of fluid flow, a turbine, accumulator, compressor, condenser, receiver, a throttling device or Tx valve and evaporator, is shown in Figure 2.

A separate accumulator may not be required as some compressors have a built in accumulator and pass any liquid present in the working fluid over the hot motor windings to cool the windings and flash the liquid to vapour. The low pressure at the output of the turbine or accumulator if provided may cause the compressor to draw a minimum of current when loaded with the power generation device and the lower temperature may ensure that heat losses to the environment can be kept to a minimum by suitable lagging of the suction line to the compressor.

Superheating of the warm vapour from the evaporator output prior to entering the turbine may cause the density of the refrigerant vapour to decrease and more heat energy to be introduced, thus increasing the power input to the generator. This may

also facilitate the use of a larger flow rate through the turbine, which in turn results in a higher efficiency of the thermodynamic cycle.

The superheating may be achieved by, for example, burning a fossil fuel to introduce heat into the cycle after the evaporator, or by passing the smaller discharge line from the compressor output through the walls of the larger compressor suction line prior to entering the power generator. A heat exchange may thus occur between the hotter working fluid vapour from the compressor output and the cooler vapour from the evaporator output passing through the suction line. The compressor discharge line may then be taken back out through the wall of the suction line prior to entering the power generator and passed into the condenser input for the removal of any residual heat to the environment. This method of superheating vapour is known in the art of air conditioning/refrigeration and thus will not be discussed further herein. An optimised system may optionally introduce both types of superheating for increased performance. A further alternative is to power the compressor by a fuel cell and use heat extracted from the fuel cell for superheating of the fluid in the thermodynamic cycle. Superheating may also be achieved by heating the air input to the evaporator fan using a suitable heating means, which could be fossil fuel or any alternative.

Referring to Figure 3, in an alternative embodiment, the hot working fluid may pass through a thermoelectric generator before entering the condenser. The thermoelectric generator incorporates a counter-current flow of cold working fluid from the Tx valve, creating a thermal potential from which further energy may be extracted through the use of suitable thermocouples. The thermoelectric generator may extract further power in the cycle where the properties of the vapour are not suitable for a turbine. If a thermoelectric generator is provided with sufficient heat transfer properties, the need for a condenser in the cycle may be avoided.

The thermoelectric generator may include two concentric tubes with a large number of interconnected semiconductor thermocouples deposited on the outer wall of the smaller tube. Hot working fluid from the compressor may pass in one direction through a smaller inner tube and cold working fluid taken from the low pressure suction line of the compressor immediately after the Tx valve may be passed in the opposite direction. The fluid passing in opposite directions ensures maximum heat transfer between the cold outer tube and the hot inner tube.

The general operation of Tx valves is well known in relation to air conditioning/refrigeration cycles and therefore is not covered further herein. However, in relation to cycles including a turbine, the inclusion of a Tx valve in the cycle has been shown experimentally to allow improved performance of power generation from the turbine. In addition, the Tx valve helps ensure that the fluid is in gaseous form as it passes through the turbine. The operation of the Tx valve may be varied to maintain required conditions in the thermodynamic cycle. In particular, the Tx valve may be bypassed as required to control the heat content of the working fluid.

In a further alternative form, the thermodynamic cycle may include two compressors in series. Between the compressors a second turbine is provided of the same or similar configuration to that on the input side of the first compressor. This allows two power extraction points in the cycle operating at different temperatures.

In order to reduce the environmental effect of the operation of the compressor, solar generated energy may be used to supply at least part of the power requirement of the compressor. The efficiency and lifetime of the solar cells is increased if they are kept at a low temperature. Therefore, the solar cells may be cooled by refrigerant in the refrigeration cycle. In Figure 4, the photovoltaic cells have refrigerant from the Tx valve flowing beneath them. This cools the solar cells and assists in the addition of heat energy to the refrigerant.

Figure 9 shows a schematic representation of an example of a construction of a photovoltaic array including photovoltaic cells 17 cooled by a refrigerant. Incident light L, and the current flow through the cells 17, act to heat the photovoltaic cells 17, which reduces their efficiency. Refrigerant is circulated below the photovoltaic cells 17 in thermally conductive tubing 20 and 21, which may be copper. A substrate on which the photovoltaic cells 17 are mounted separates the tubing 20, 21 from the cells 17.

Referring to Figure 5, an exploded view of a turbine for use in any of the cycles referred to above is generally referenced 1. However, those skilled in the art will recognise that the turbine described herein in combination with a suitable nozzle may have application to extraction of energy from any suitable fluid flow where a pressure differential exists. It is anticipated that the turbine 1 will be placed in a thermodynamic

cycle and that it will receive a gaseous fluid jet. However, alternative applications may be possible.

The turbine 1 includes at least two opposing substantially radially orientated discs 2, in Figure 5 five discs, although any number may be provided as required. A blade ring including a plurality of blades 5 located about its periphery is provided. The blades 5 are located to in use extend around the discs 2. A turbine casing having two parts 6A and 6b enclose the longitudinal axes of the turbine 1. The discs 2 and blades 5 may be fixedly engaged to a shaft 3 so that rotation of the discs 2 causes synchronous rotation of the shaft 3. However, gearing may be provided and the discs 2, blades 5 and or shaft 3 may rotate asynchronously if required.

The blades 5 may be angled at any required angle, possibly of the order of 30° or 45° to the tangent of the discs 2. The blades 5 preferably have an aerofoil shape wherein the receiving surface is curved to cause smooth angular acceleration of a fluid jet. This may reduce the turbulence added to the fluid jet. The inner peripheral edge of the blades may be separated from the outer peripheral edge of the discs 2 by a predetermined extent, which may be determined experimentally or otherwise. In an alternative embodiment it is envisaged that the blades 5 may be omitted by removing the blade ring. In this embodiment the nozzle, (see Figure 7), would protrude between the adjacent plates. Alternatively the blades 5 may be slightly inset from the rotor edge allowing the nozzle to protrude between the adjacent plates and be very close to the blades at the same time.

Central of the discs 2 is an aperture 7, from which fluid is extracted from the rotor 1. Complementary apertures are provided in the blade ring and turbine casing 6A, shown as 7B, which align with aperture 7 when the turbine 1 is assembled. The discs 2 may preferably be bolted to the rotor casing 6B around its periphery by bolts and spaced apart by spacers (not shown). This leaves the aperture 7 free of obstruction, reducing potential turbulence in the spiral flow of fluid out of the aperture 7. This may be important for any subsequent turbine stages that may be added as described later herein.

It will be appreciated by those skilled in the relevant arts that many variables of the turbine 1 may be varied. For example, the shape, number, angle and location of the

blades 5 may be varied as required. The number, separation and surface area of the discs 2 may be varied and the dimensions, location and number of the apertures 7 may be varied. Other dimensions, relative locations and number of components may be varied as required to obtain a specified performance.

Referring to Figure 6, a side view of a turbine 1 is shown together with a nozzle casing 8. The turbine 1 fits inside the nozzle casing 8, as shown by dotted lines and thus also acts as a turbine chamber. A nozzle aperture 9 is provided to receive a nozzle 10 (see Figure 7). The nozzle 10 provides the feed of fluid to the turbine 1. The nozzle is oriented at an angle ϕ to the tangent of the discs 2, where ϕ is any suitable angle, approximately 12° in one embodiment. The nozzle exit is preferably located within approximately 0.5 mm from the leading edge of the blades 5. The blades 5 receive the jet of fluid from the nozzle 10 and direct it onto the discs 2. This angular acceleration of the fluid provides a turning moment on the turbine 1. The shape and orientation of the blades is such to direct the fluid into the periphery of the discs 2.

Although the turbine in the accompanying representations has a single nozzle 10, more than one nozzle may be provided as required. The relative positioning and orientation of any subsequent nozzles may be varied to optimise performance. However, it has been found experimentally that the combination of sonic operation of the nozzle 10 and nozzle exit to blade separation of within approximately 0.5 mm result in improved performance over subsonic operation and significantly greater separation distances. The discs 2 may optionally be omitted, however reduced performance may result.

In use, the pressure at the central aperture 7 is less than that at the nozzle 10. Therefore, the fluid moves from the nozzle to the aperture 7. As the fluid is directed towards the periphery of the discs 2, the momentum of the fluid causes it to spiral around the discs 2 towards the aperture 7. The high speed vapour travelling over the surfaces of the discs 2 may create a turning moment on the discs 2 due to viscosity between the jet and the disc surfaces. This turning moment is in the same direction that results from angular acceleration of the jet of fluid by the blades 5. The fluid may spiral into the centre of the rotors, and is extracted through the central aperture 7.

In a preferred form of the invention, the nozzle 10 is of converging cross section and dimensioned such that the difference in pressure between the fluid upstream of the nozzle 10 and the fluid at an outlet is sufficient to cause constriction of the flow at the throat of the nozzle 10 in order to cause the vapour to travel at the local speed of sound. The speed may increase as the vapour expands past the nozzle.

Preferably the pressure differential across the turbine 1 may also be sufficient to accelerate the vapour to supersonic speeds as the cross-sectional area of the jet increases downstream of the nozzle 10. In the example shown the discs 2 are substantially parallel, the jet of fluid travelling between the discs 2 diverging in the plane of the discs 2 and thereby accelerating to supersonic speeds. In order to ensure a sonic flow rate of the jet of fluid at the nozzle, the cross-sectional area of the jet when passing through the discs 2 should not be smaller than the area of the nozzle. However, in order to cause drag on the plates 2 by the fluid jet, the plates 2 should have a narrow gap between them. The relatively large surface area of the plates 2 assists in balancing these requirements and a required separation of the plates 2 to obtain a specific performance may be determined theoretically and or through experiment.

Thus, the turbine 1 effectively has two generators of a turning moment, the first resulting from angular acceleration of the jet of fluid by the blades 5 and the second resulting from viscosity between the relatively moving jet and the discs 2.

The nozzle 10 may be of fixed geometry, or more preferably may be of adjustable geometry enabling control over the operation of the turbine 1. The cross-sectional area of the nozzle entrance may be varied electronically. This may be achieved more easily than an alternative of varying the cross-section of the nozzle exit 16. The area may be electronically controlled through the provision of a solenoid actuator or any other suitable control means. If a solenoid actuator is used, the nozzle entrance may be progressively "pinched" and released by actuation of the solenoid. Referring to Figure 8, enthalpy rich fluid enters the nozzle 10 through an inlet tube 11. Solenoids 12, which are magnetically coupled to plungers 13 are controlled electronically through terminals 14. The area of the nozzle entrance 15 may thus be reduced to create a smaller cross-sectional area. The solenoid or other control means may have as an input the rotational velocity of the turbine 1 and or the power output of

the turbine system, thus creating a feedback control system. The control system may enable modulation between sonic and sub-sonic flow of the fluid within the nozzle exit as required.

In order to extract more energy from the working fluid, multiple turbines 1 may be cascaded. Figure 10 shows a schematic representation of a cross-section of three vertically cascaded turbines 1A, 1B and 1C although two or more than three stages may alternatively be provided. Fluid enters the cascaded turbines 1A-C from the nozzle 10 as a jet J and is expelled through aperture E3. The fluid jet J impacts the blades 5A and is directed onto plates 2A, to be extracted through aperture E1. As the fluid jet J exits E1, its flow forced radially outward due to the impediment presented by a first fluid stop 22. The outward flow may be assisted by centrifugal force of the spiralling fluid flow. The fluid jet J must then move to the edge of the fluid stop 22 through a fluid channel created by the fluid stop 22 and lower surface of the turbine 1A and is received by blades 5B of turbine 1B. The flow then enters plates 2B, proceeds through aperture E2 around a second fluid stop 23 onto the turbine 1C. The fluid stop 22 and or fluid stop 23 may alternatively have a conical or frustoconical shape converging upwardly in Figure 10. By having multiple stages, an increased amount of energy may be extracted from the fluid flow.

The edges of turbines 1B and 1C may be sealed to prevent flow around the side of the turbine. Alternatively, a sufficiently high flow resistance path may be provided, for example by providing a narrow gap to the edge of the turbines to the inside surface of the nozzle casing 8.

In an alternative form, the central aperture or apertures through the drag plates may have a spiralling centre line complementary with the expected path of the fluid jet. However, for simplicity and to avoid introducing significant turbulence to the flow, a single central aperture extending along and parallel to axis of rotation is preferred.

Although in Figure 10 each turbine stage 1A, 1B, 1C is shown having substantially the same configuration and dimensions, variations between stages may be possible. For example, the second and third stages may include only drag plates 2B and not blades 5B or vice versa. The radius of subsequent stages may be different, for

example, turbine 1B may have a smaller radius than turbine 1A. Also, the number, orientation and positioning of the drag plates and blades may vary from stage to stage.

It will be appreciated by those skilled in the art that a larger pressure differential between the inlet to turbine 1A and aperture E3 may be required to maintain a required flow through the cascaded turbines than for a single stage turbine. Furthermore, it will be appreciated that sufficient sealing about the periphery of the turbine stages is required to force the fluid flow through each turbine stage. Each stage may have a slightly different configuration, which may be optimised for the expected fluid flow at each stage. For example, the separation and number of plates 2 may be varied and or the angle of the blades 5 varied. Further variations may become apparent to those skilled in the art.

In order to enable the turbine to start rotating and to avoid stalling the turbine once a load is applied, a soft-start mechanism may be provided. Soft-starting may be required for particular turbine designs. A preferred soft start mechanism operates by ramping the electric field between the rotor and stator of an electric generator. This may be achieved by passing a direct current through the windings from an external source to reduce the electric/magnetic coupling during start-up. The direct current may be applied again if the rotor speed reduces below a predetermined level. The soft start may mechanism may be used in conjunction with an electronically modulated nozzle, controlled by a suitable control system.

Thus, the present invention provides a means of extracting energy from a fluid flow, which preferably forms part of a thermodynamic cycle. A compressor in the fluid flow may have a supply from an energy source requiring a controlled operating temperature for optimum operation, such as photovoltaic cells. Control of the output of the system may be achieved by a controlled aperture nozzle.

Referring now to Figure 11 a thermoelectric generator according to a further possible embodiment of the invention is referenced generally by arrow 100. This utilises two concentric spheres 101, 102. This has advantages over the tubular design including:

- maximising surface area in a minimum space enabling a larger number of semiconductor thermocouples to be packed into a given space;

- facilitating the deposition of semiconductor material in an evaporation chamber;
- and enabling a larger volume of working fluid being brought into intimate contact with the thermocouples in both the hot and cold sides and thereby providing greater heat transfer.

In Figure 11 cold liquid/vapour will arrive from the Tx valve in the direction of arrow A into the cold outer sphere 101 where it will be heated by contact with the hot inner sphere 102, through which the hot working fluid is passing in the direction of arrow X, the cooled working fluid exiting in the direction of arrow Y. The now warmed vapour will exit to the evaporator in the direction of arrow B.

It is mentioned that a further form of superheating may be achieved by using an evaporator with a circular tubing arrangement and a warm air heater. The circular tubing arrangement has a major advantage over a conventional evaporator because a circular shape is less likely to adversely interfere with a hypersonic gas flow than one which zig zags with right angled bends.

It is also mentioned that for semiconductor deposition on the inner sphere 102 in Figure 11 the shadow masks may be simply attached by positive and negative terminal studs supported by insulated nuts on the outer sphere 101 and extending through to insulated captive screw attachments on the surface of the inner sphere 102.

Referring now to Figure 12, in a concentric spherical thermoelectric generator referenced 110 the outer surface of the inner sphere 111 is coated in such a way as to deposit a large number of thermoelectric devices (thermocouples) 112 which are inter-connected serially or in series/parallel as required. The electrical connections are suitably brought out to gas sealed terminals mounted on the outer surface of the outer sphere 113. The n-p junctions may be applied using thin film techniques to minimise the insulation about the inner sphere 111.

Where in the foregoing description reference has been made to specific components or integers of the invention having known equivalents then such equivalents are herein incorporated as if individually set forth.

Although this invention has been described by way of example and with reference to possible embodiments thereof, it is to be understood that modifications or improvements may be made thereto without departing from the scope of the appended claims.

Claims

1. A turbine including:

- a rotor chamber;

- a rotor rotatable about a central axis within said rotor chamber and including a plurality of blades located about its periphery, at least one aperture located centrally of said rotor and extending through said rotor generally along or parallel to said central axis and at least two drag surfaces between said at least one aperture and said blades, said drag surfaces located relative to each other to in use create a drag force on fluid (as herein defined), flowing between them;

- at least one nozzle for communicating fluid at a first pressure onto said blades; and

- fluid receiving means operable at a second pressure lower than the first, the fluid receiving means adapted to receive fluid from said at least one aperture;

wherein said rotor is adapted to in use receive fluid from said nozzle and direct the fluid to between said drag surfaces so that the fluid spirals inwardly towards said at least one aperture, thereby causing rotational force to be applied to the rotor about said central axis.

2. The turbine of claim 1, wherein said at least one nozzle is adapted to communicate fluid through its exit at the local sonic or hypersonic velocity.

3. The turbine of claim 3, wherein the exit of said nozzle is located within approximately 0.5mm from the leading edge of said blades.

4. The turbine of any one of the preceding claims, wherein said drag surfaces are substantially planar and substantially parallel to each other.

5. The turbine of any one of the preceding claims, wherein said blades are separated from an outer periphery of said drag surfaces by a predetermined extent.

6. The turbine of any one of the preceding claims, wherein a plurality of nozzles are provided at different heights relative to said blades.

7. The turbine of any one of the preceding claims, wherein said blades are shaped to direct fluid received from said nozzle onto a peripheral portion of said drag plates at an angle substantially tangential to the rim of said at least one aperture.

8. The turbine of any one of the preceding claims, wherein one end of said at least one central aperture is closed and said fluid receiving means receives fluid from the open end of said at least one aperture.

9. The turbine of any one of the preceding claims, wherein said fluid receiving means is a fluid channel feeding towards the periphery of a second rotor mounted coaxially with said first rotor within said rotor chamber.

10. The turbine of claim 9, wherein said fluid channel includes a fluid stop extending across said fluid receiving means, thereby forcing fluid to move radially outward from said central axis of rotation.

11. The turbine of either claim 9 or claim 10, wherein said second rotor includes at least two drag plates about at least one centrally located aperture feeding into a further fluid receiving means.

12. The turbine of any one of claims 9 to 11, wherein said second rotor includes a plurality of blades located about its periphery to receive fluid from said fluid channel.

13. The turbine of claim 11 or claim 12 when dependent on claim 11, wherein said further receiving means operates at a third pressure lower than said second pressure.

14. A turbine system including a turbine as claimed in any one of claims 1 to 8, wherein the rotor chamber contains a plurality of said rotors mounted coaxially, wherein each rotor is separated from its adjacent rotor or rotors by a fluid stop extending across the at least one aperture, said fluid stop defining part of a fluid channel, which in use directs fluid from the at least one aperture of one rotor to a peripheral portion of an adjacent rotor.

15. An electric generator including:

- a rotor chamber;

- a rotor rotatable about a central axis within said rotor chamber and including a plurality of blades located about its periphery, at least one aperture located centrally of said rotor and extending through said rotor generally along or parallel to said central axis and at least two drag surfaces between said at least one aperture and said blades, said drag surfaces located relative to each other to in use create a drag force on fluid flowing between them;

- at least one nozzle for communicating fluid at a first pressure onto said blades;

- fluid receiving means operable at a second pressure lower than the first, the fluid receiving means adapted to receive fluid from said at least one aperture; and

conversion means for converting kinetic energy embodied in rotation of said rotor to electric potential;

wherein said rotor is adapted to in use receive fluid from said nozzle and direct the fluid to between said drag surfaces so that the fluid spirals inwardly towards said at least one aperture.

16. The electric generator of claim 15, wherein said at least one nozzle is adapted to communicate fluid through its exit at the local sonic or hypersonic velocity.

17. The electric generator of either claim 15 or claim 16, wherein the exit of said nozzle is located approximately within 0.5 mm from the leading edge of said blades.

18. The electric generator of any one of claims 15 to 17, wherein one end of said at least one central aperture is closed and said fluid receiving means receives fluid from the open end of said at least one aperture.

19. The electric generator of any one of claims 15 to 18, wherein said fluid receiving means is a fluid channel to direct fluid towards the periphery of a second turbine.

20. The electric generator of claim 19, wherein said fluid channel includes a fluid stop extending across said fluid receiving means, thereby forcing fluid to move radially outward from said central axis of rotation.

21. The electric generator of either claim 19 or claim 20, wherein said second turbine includes at least two drag plates about at least one centrally located aperture feeding into a further fluid receiving means.

22. The electric generator of any one of claims 19 to 21, wherein said second turbine includes a plurality of blades located about its periphery to receive fluid from said fluid channel.

23. The electric generator of claim 21 or claim 22 when dependent on claim 21, wherein said further receiving means operates at a third pressure lower than said second pressure.

24. An electric generator including a turbine as claimed in any one of claims 1 to 8 including a plurality of rotors mounted coaxially within said rotor chamber and conversion means to convert rotation of said plurality of rotors to electric potential, wherein each turbine is separated from its adjacent turbine or turbines by a fluid stop extending across the at least one aperture, said fluid stop defining part of a fluid channel which in use directs fluid from the at least one aperture of one turbine to a peripheral portion of an adjacent turbine.

25. A thermodynamic cycle for producing electric potential including:

- the electric generator of any one of claims 15 to 24;
- a fluid cycle for supplying fluid to the at least one nozzle of said electric generator and for receiving fluid from a fluid output of said electric generator and including means to increase the enthalpy of said fluid from said output of said electric generator for supply to said at least one nozzle.

26. The thermodynamic cycle of claim 25 including a compressor in said fluid cycle, wherein said electric generator is located in the cycle with the fluid output feeding the input of the compressor.

27. The thermodynamic cycle of claim 26, wherein said compressor is at least partially powered by photovoltaic cells, wherein said photovoltaic cells are cooled by fluid within the fluid cycle.

28. The thermodynamic cycle of any one of claims 25 to 27 further including a thermoelectric generator fed by fluid from different parts of the cycle having a temperature differential.

29. The thermodynamic cycle of any one of claims 25 to 28 further including a throttling device upstream of said electric generator.

30. The thermodynamic cycle of claim 26, wherein said compressor is at least partially powered by fuel cell and heat from said fuel cell is used to heat fluid in the fluid cycle.

31. The thermodynamic cycle of any one of claims 25 to 30 including a control system to control operation of said at least one nozzle between subsonic and sonic operation within the nozzle's exit.

32. A method of generating electric potential including:

- providing a rotor within a rotor chamber, the rotor rotatable about a central axis within said rotor chamber and including a plurality of blades located about its periphery, at least one aperture located centrally of said rotor and extending through said rotor generally along or parallel to said central axis and at least two drag surfaces between said at least one aperture and said blades, said drag surfaces located relative to each other to in use create a drag force on fluid, (as herein defined), flowing between them;

- communicating a fluid at a first pressure onto said blades and direct the fluid between said drag surfaces so that the fluid spirals inwardly towards said at least one aperture;

- receiving fluid at a second pressure lower than the first from said at least one aperture; and

- converting kinetic energy embodied in rotation of said rotor to electric potential.

33. The method of claim 32, including communicating said fluid onto said blades through a nozzle, wherein the fluid through the nozzle's exit is travelling at the local sonic or hypersonic velocity.

34. An electric generator including:

- a rotor chamber;
- a rotor rotatable about a central axis within said rotor chamber and including a plurality of blades located about its periphery and at least one aperture located centrally of said rotor and extending through said rotor generally along or parallel to said central axis;
- at least one nozzle for communicating fluid from said fluid supply means at a first pressure onto said blades, the nozzle adapted to provide fluid from its exit at or above the local sonic velocity;
- fluid receiving means operable at a second pressure lower than the first, the fluid receiving means adapted to receive fluid from said at least one aperture;
- conversion means for converting kinetic energy embodied in rotation of said rotor to electric potential;

wherein said rotor is adapted to in use receive fluid from said nozzle, thereby causing rotational force to be applied to the rotor about said central axis.

35. The electric generator of claim 34, wherein the nozzle exit is located within approximately 0.5 mm from a leading edge of said blades.

36. The electric generator of either claim 34 or claim 35, further including at least two drag surfaces between said at least one aperture and said blades, said drag surfaces located relative to each other to in use create a drag force on fluid (as herein defined), flowing between them.

37. A thermoelectric generator including first fluid communication channel including a first substantially spherical enlargement and a second fluid communication channel including a second substantially spherical enlargement of larger diameter than the first, wherein said first and second substantially spherical enlargements are

substantially coaxial and wherein the generator includes thermocouple means provided about the periphery of the first spherical enlargement, which in use provides electric potential output when a temperature differential exists between fluid in said firs and second fluid communication channels.

38. The thermoelectric generator of claim 37, wherein said thermocouple means is a plurality of silicon n-p and p-n junctions applied to the surface of the first spherical enlargement using thin film techniques.

39. The thermodynamic cycle of claim 28, wherein the thermoelectric generator is a thermoelectric generator as claimed in claim 36 or claim 37.

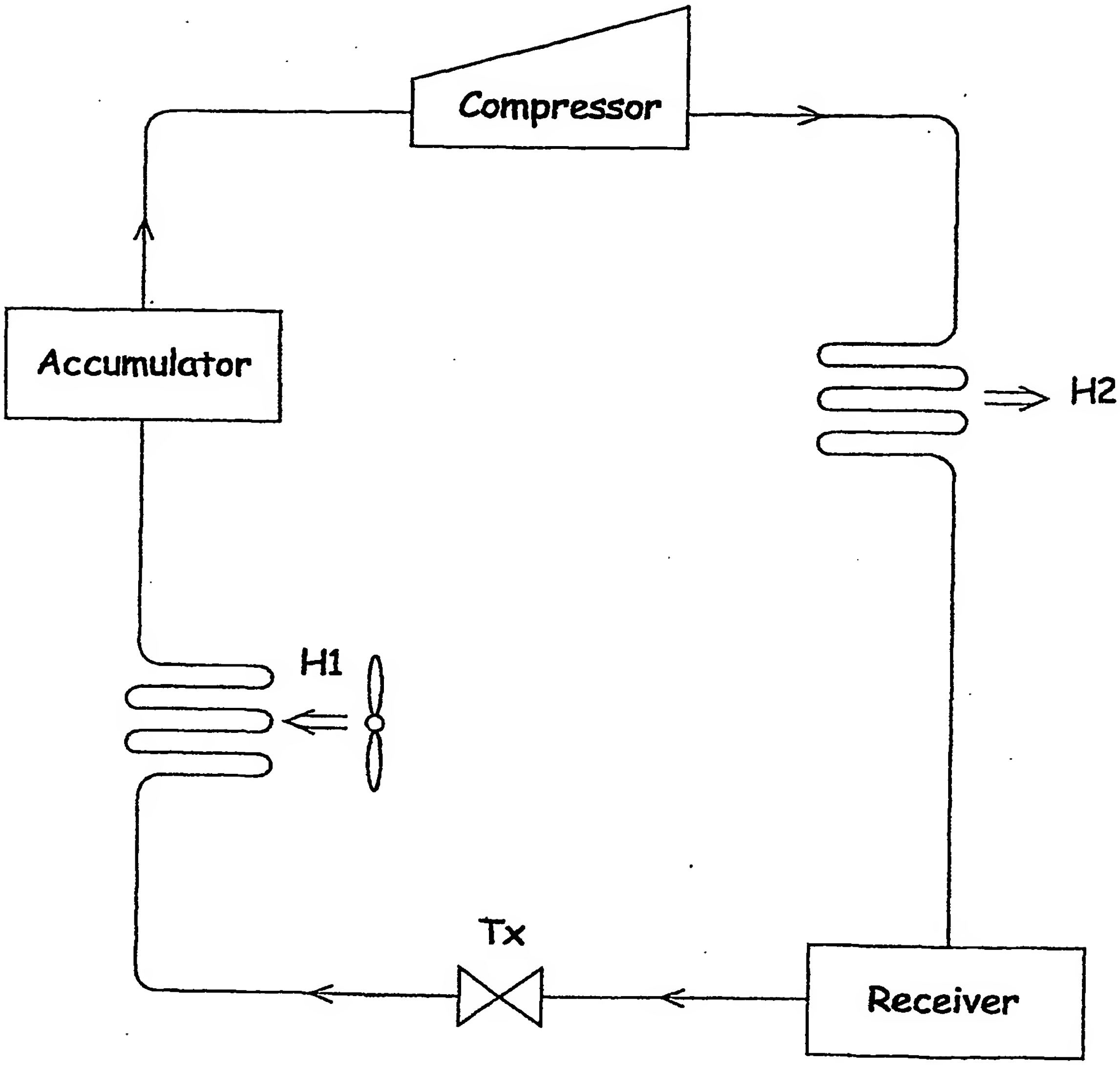
40. A turbine substantially as herein described with reference to Figures 5 to 7 or Figure 10.

41. An electric generator substantially as herein described with reference to Figures 2 to 12.

42. A thermodynamic cycle for producing electric potential substantially as herein described with reference to Figures 2 to 12.

43. A turbine as claimed in any one of the claims 1 to 14 and adapted to be provided with said fluid by a fuel burning means.

44. A turbine as claimed in claim 43, wherein the fuel is gas or a fossil fuel and the fuel burning means is adapted to provide said fluid as a supersonic heated working fluid vapour.



Prior Art

Figure 1

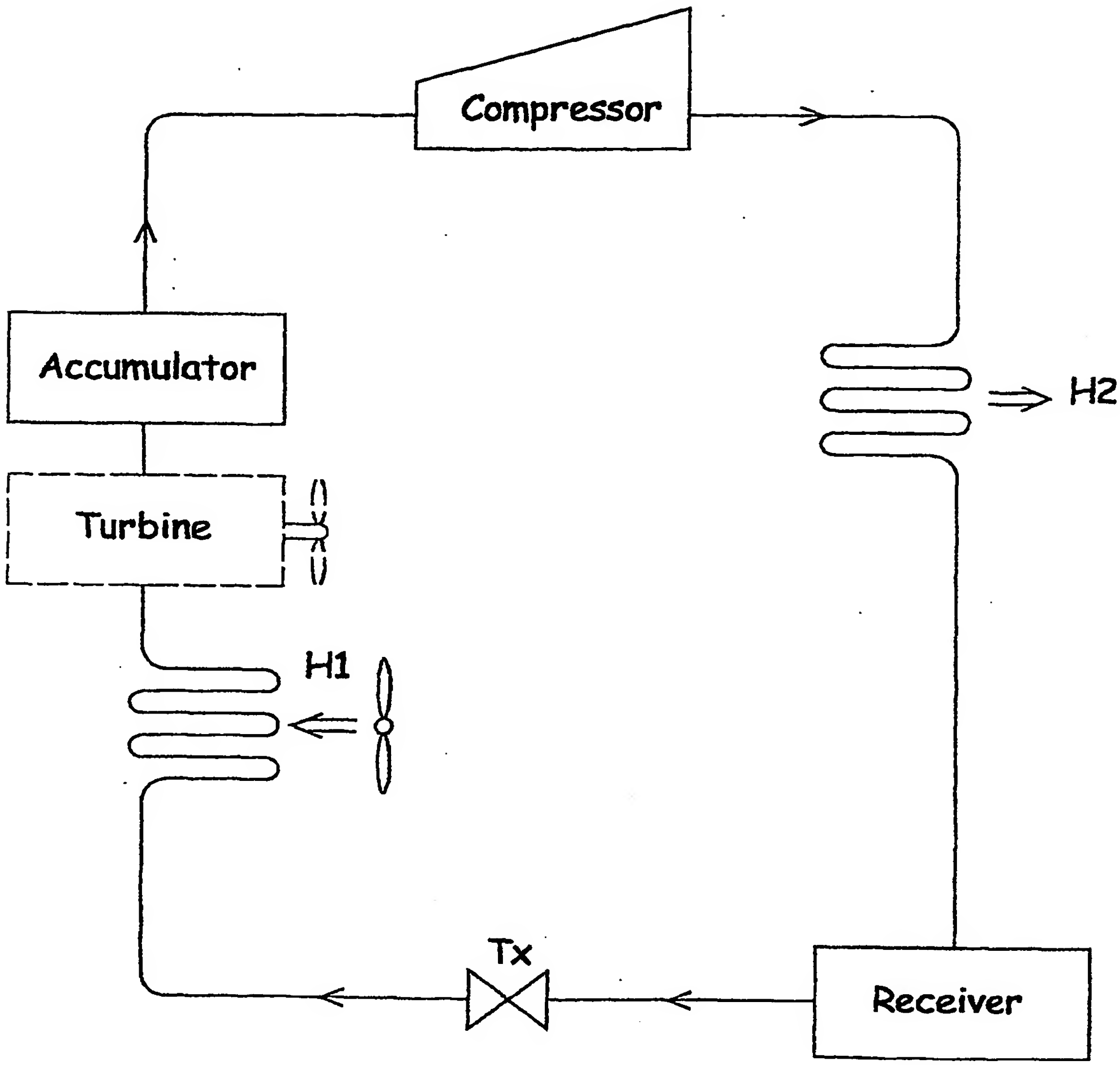


Figure 2

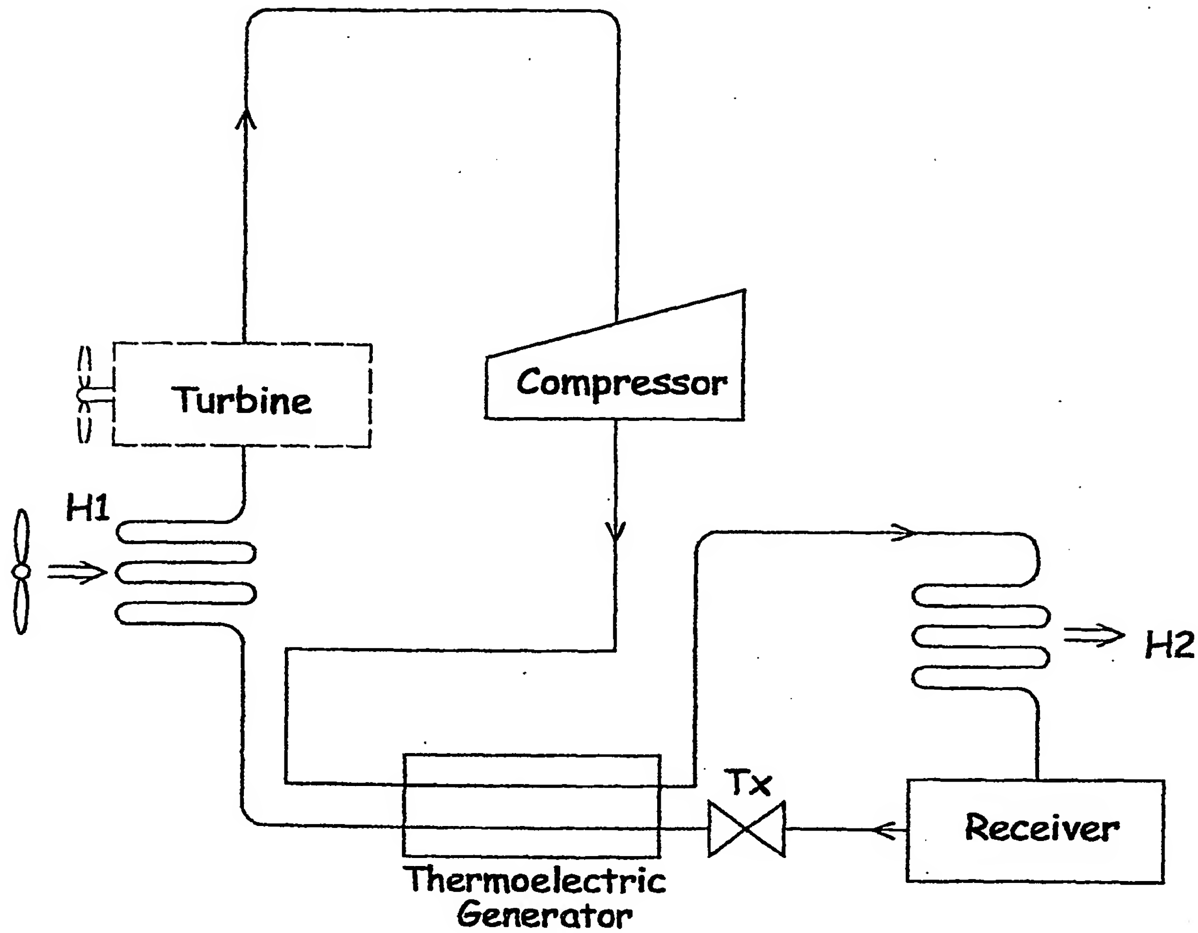

Turbine
Compressor
H1
H2
Tx
Receiver
Thermoelectric Generator

Figure 3

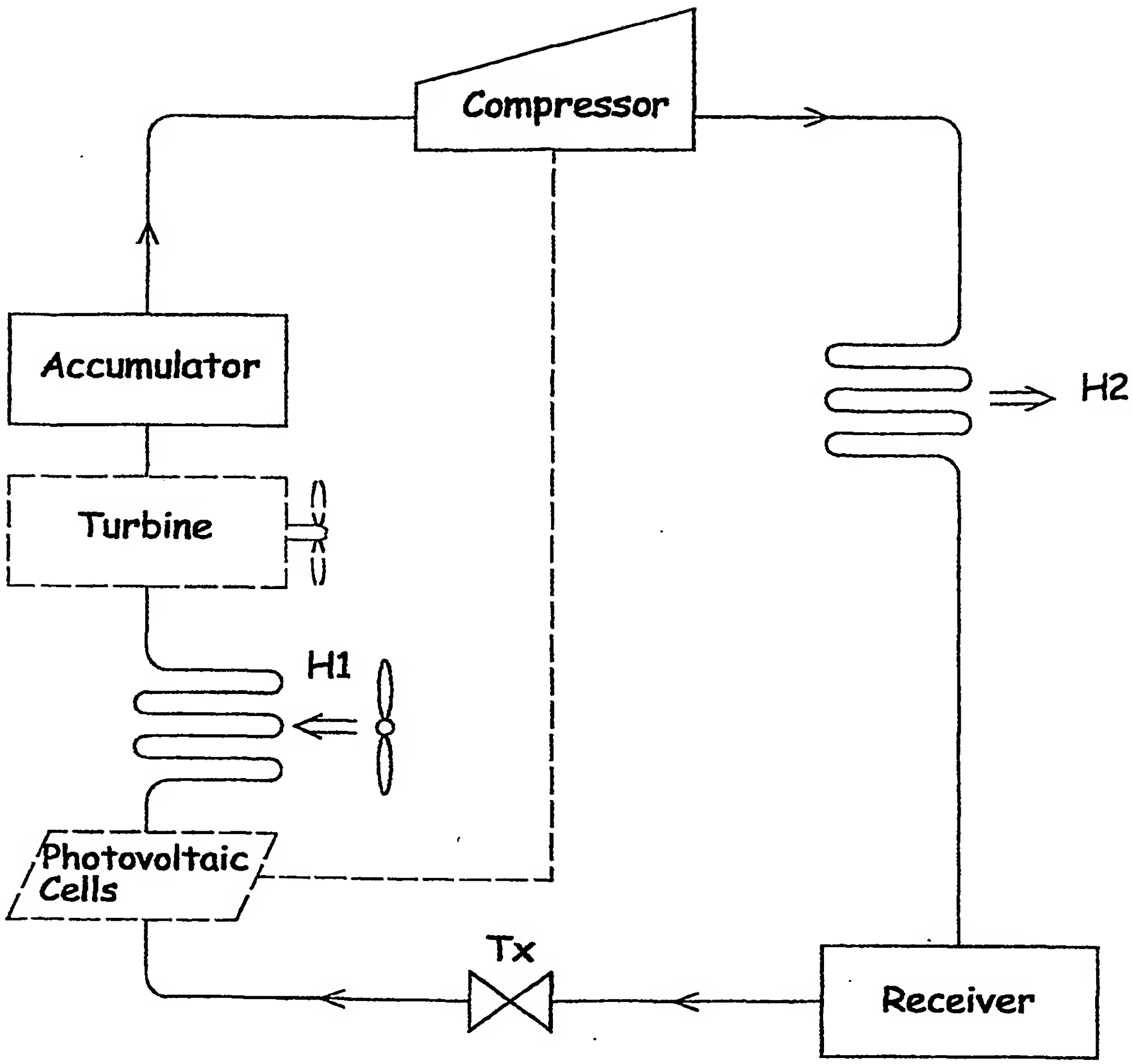

Compressor
Accumulator
Turbine
H1
H2
Photovoltaic Cells
Tx
Receiver

Figure 4

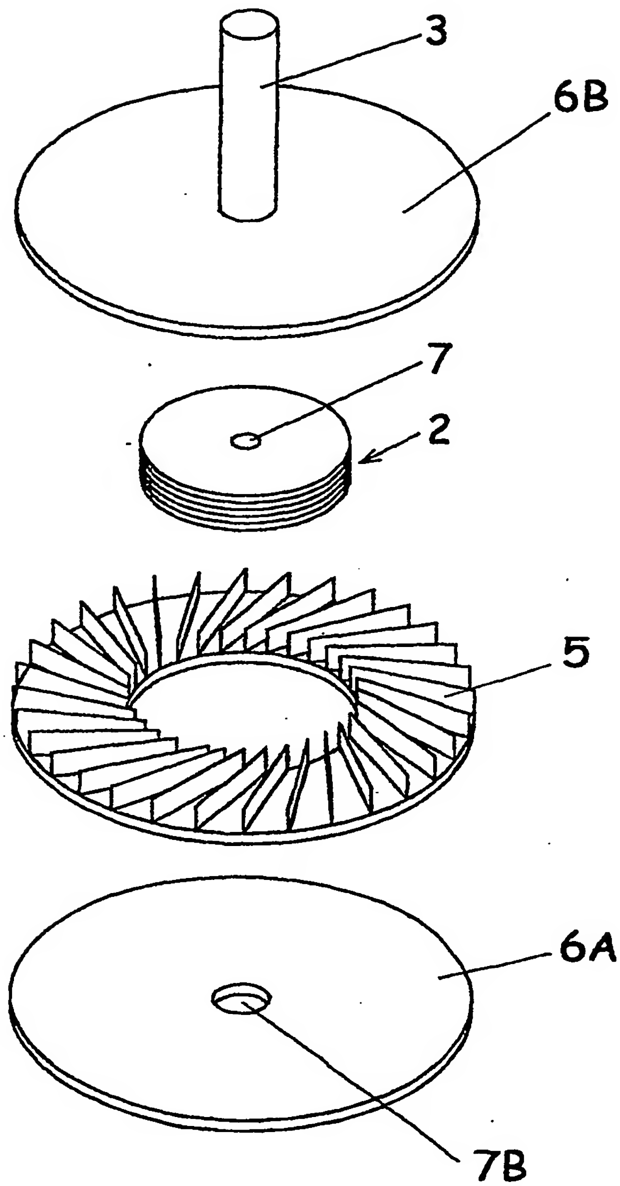


Figure 5

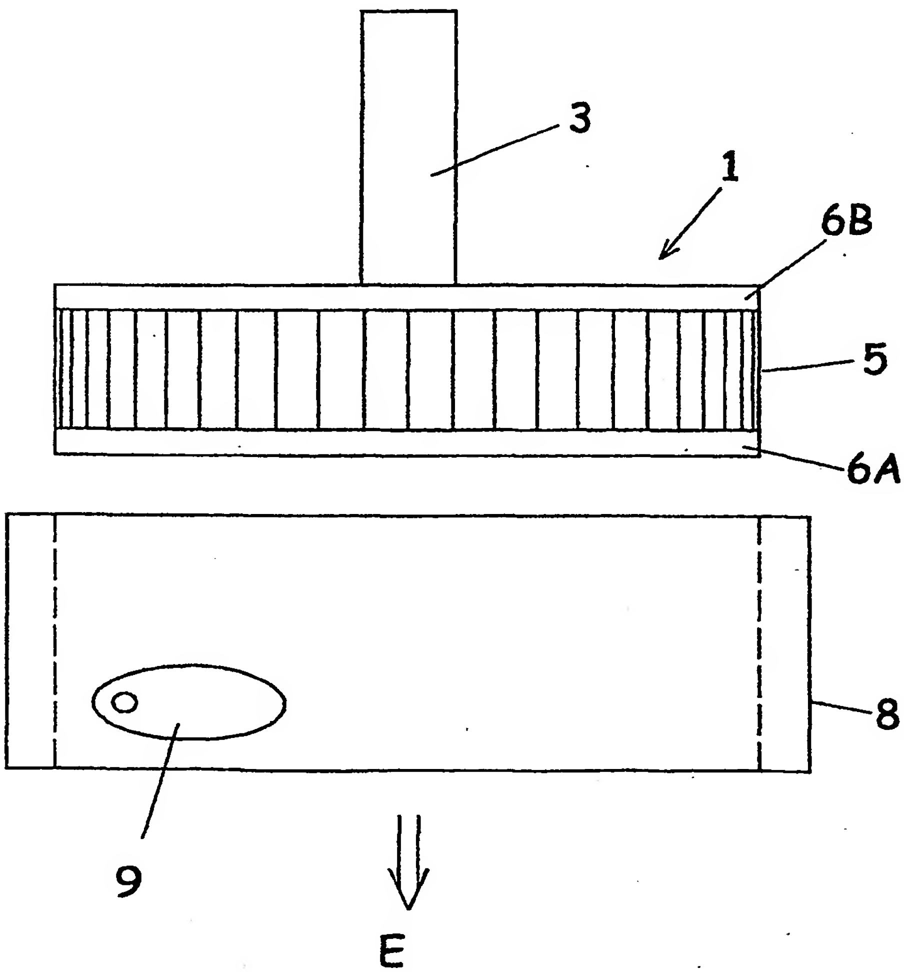


Figure 6

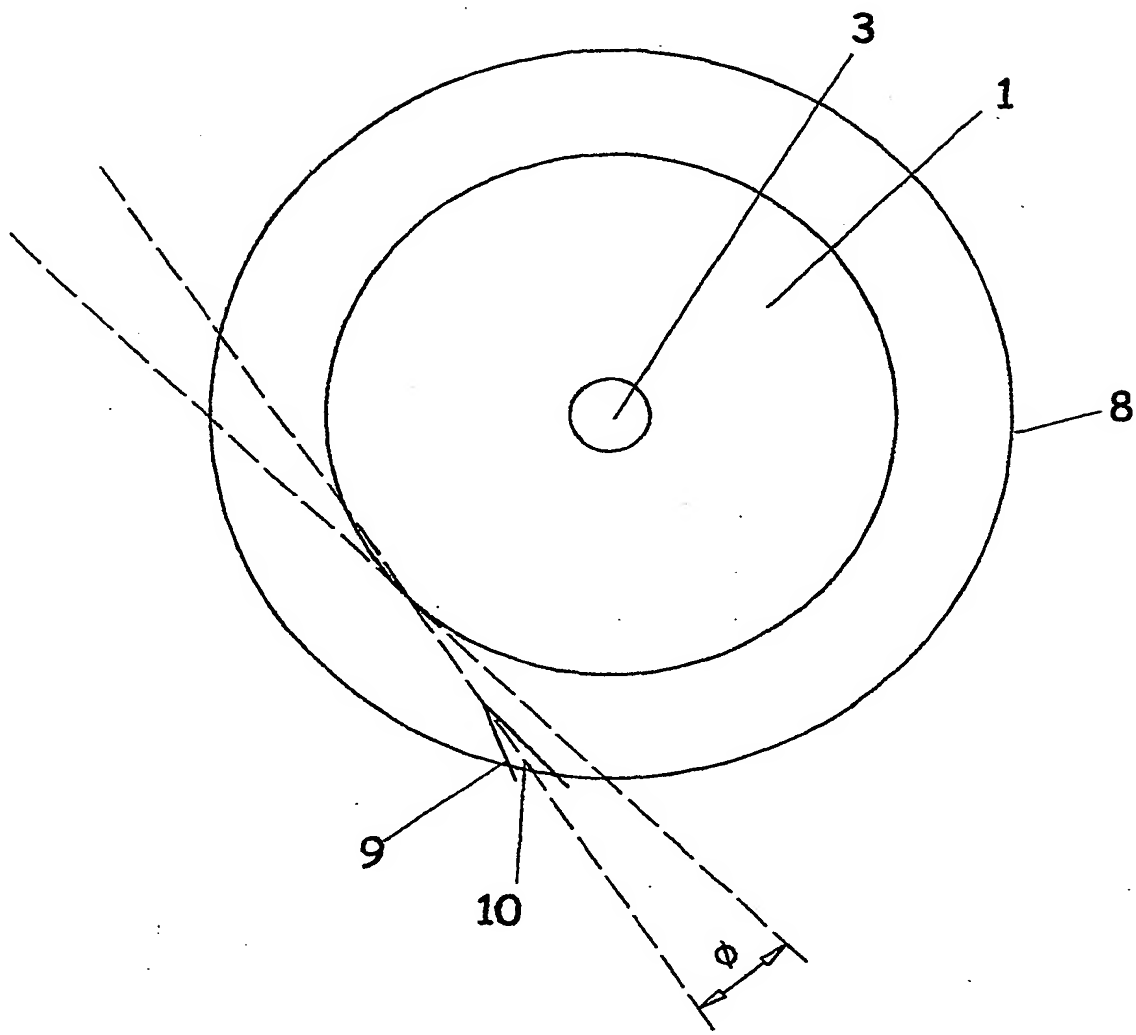


Figure 7

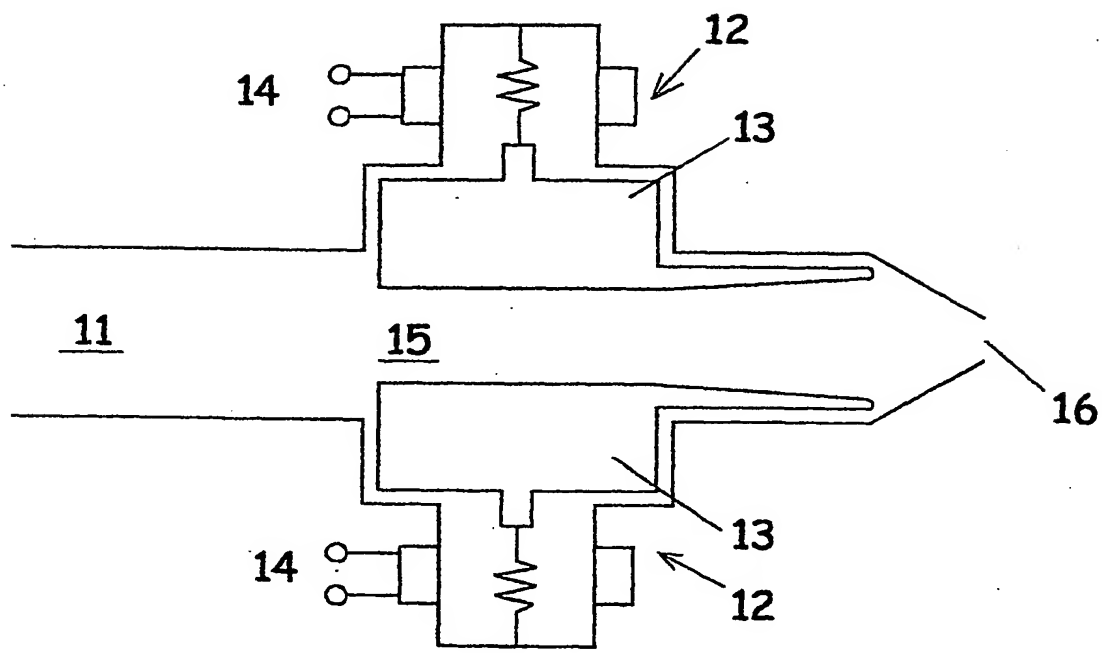


Figure 8

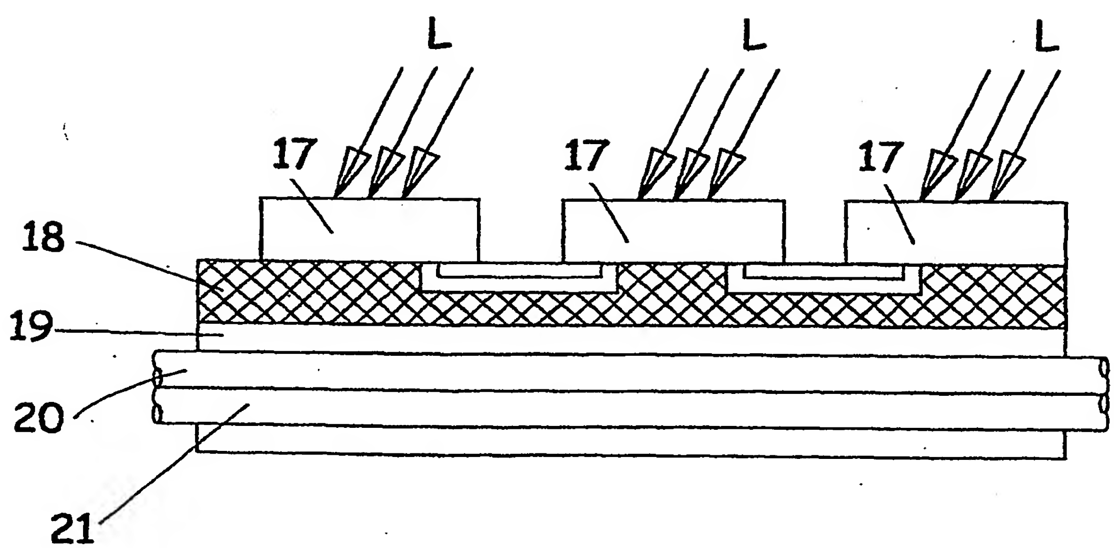


Figure 9

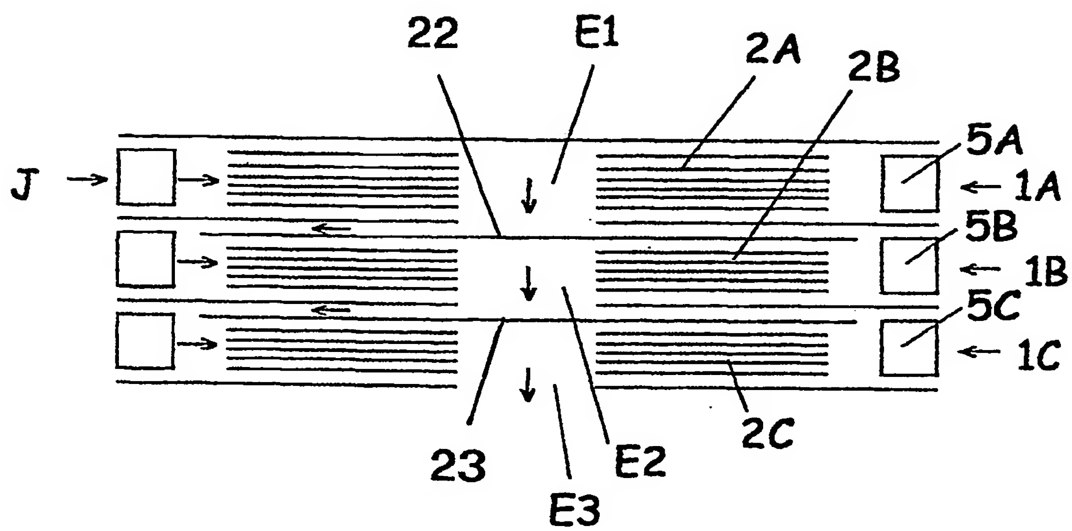


Figure 10

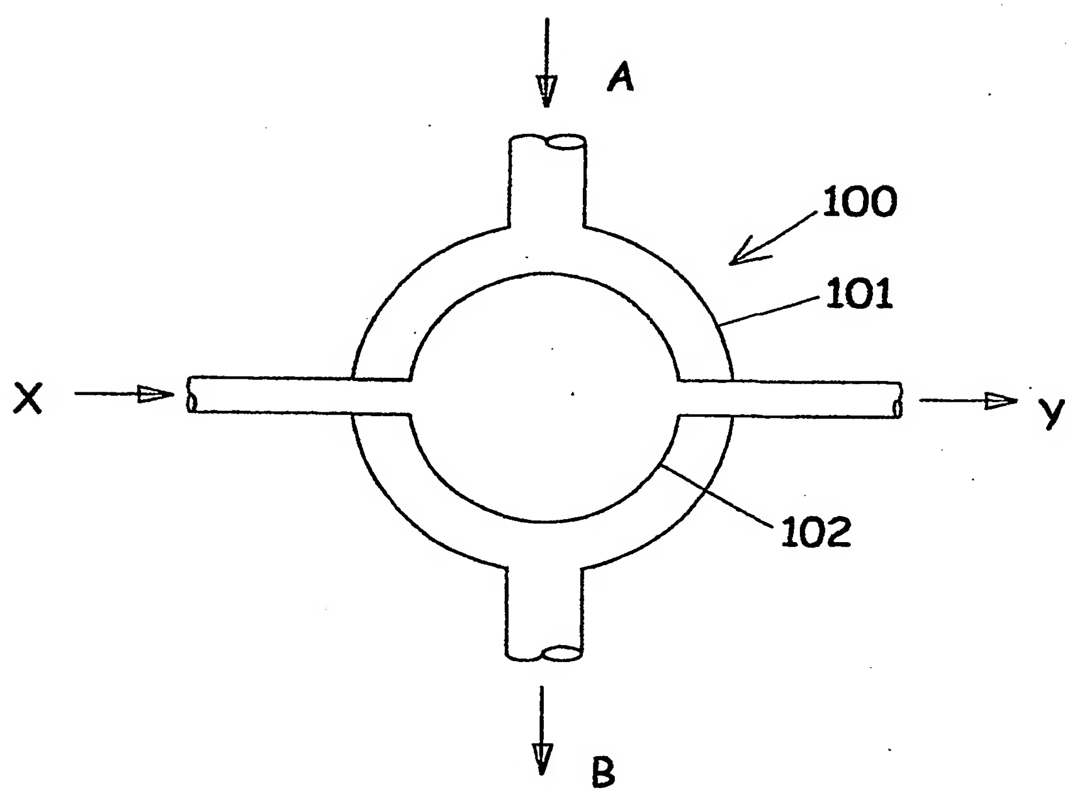


Figure 11

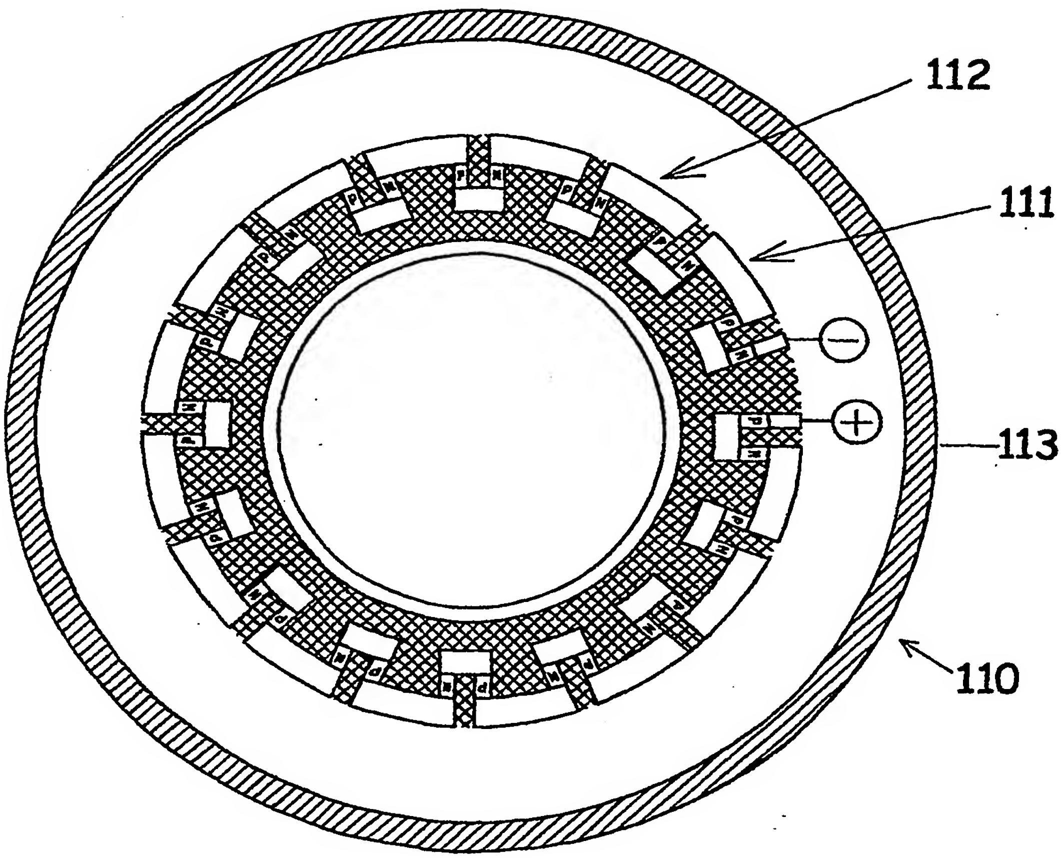


Figure 12

INTERNATIONAL SEARCH REPORT	International application No. PCT/AU01/00813

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: F01D 1/08, 5/04, 1/36, 9/02, 17/14; H01L 35/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F01D 1/06, 1/08, 5/04, 1/36, 9/02, 17/14; H10L 35/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

AU : IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

DWPI with keywords : blade?, vane?, sound+, +sonic+, drag+, friction+, Thermoelectric, thermocouple, fluid, liquid, refrigerant, spehre?, spherical+, shell?

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	US 4255081A (OKLEJAS et al.) 10 March 1981	
X	See the whole document	1, 3-15, 17-33, 43, 44
Y	See the whole document	2, 16
	US 4641498A (MARKOVITCH et al.) 10 February 1987	
Y	See the whole document	34-36
	US 5676522A (POMMEL et al.) 14 October 1997	
Y	Abstract and figures	2, 16, 34-36

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" Document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 August 2001	6 SEPTEMBER 2001
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer ASANKA PERERA Telephone No : (02) 6283 2373

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU01/00813

C (Continuation).	DOCUMENTS CONSIDERED TO BE RELEVANT	
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 1013248A (WILKINSON) 2 January 1912 See the whole document	1, 3-15, 17-33
A	US 4201512A (MARYNOWSKI et al.) 6 May 1980 See the whole document	1-33, 43, 44
A	US 4534699A (POSSELL) 13 August 1985 See the whole document	1-33, 43, 44
A	US 2043788A (ADAIR) 9 June 1936 See the whole document	1-33, 43, 44
Y	US 5361587A (HOFFMAN) 8 November 1994 See the whole document	37, 38
Y	Derwent Abstract Accession No. 84-048526/08, Class S02, SU 1015308A (PODKIDOV) 30 April 1983 Abstract and Figure	37, 38
A	US 5929372A (OUDOIRE et al.) 27 July 1999 See the whole document	37, 38

Supplemental Box
(To be used when the space in any of Boxes I to VIII is not sufficient)

Continuation of Box No: II

The international application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept. In coming to this conclusion the International Searching Authority has found that there are different inventions as follows:

1. Claims 1-33, 39-44 are directed to a turbine (claims 1-14, 40, 43, 44), an electric generator (claims 15-24, 41), a thermodynamic cycle for producing electric potential using the electric generator (claims 25-31, 39, 42) and a method of generating electric potential (claims 32-33). It is considered that a bladed rotor with drag surfaces which spirals inwardly a fluid received thereinto towards an aperture located centrally thereof comprises a first "special technical feature".

2. Claims 34-36 are directed to an electric generator. It is considered that a rotor with an associated nozzle adapted to provide fluid from its exit at or above the local sonic velocity comprises a second "special technical feature".

3. Claims 37-38 are directed to a thermoelectric generator. It is considered that the first and second fluid communication channels including substantially spherical enlargements and providing an electric potential output when a temperature differential exists between the fluid in the two channels comprises a third "special technical feature"

Since the abovementioned groups of claims do not share any of the technical features identified, a "technical relationship" between the inventions, as defined in PCT rule 13.2 does not exist. Accordingly the international application does not relate to one invention or to a single inventive concept, a priori.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/AU01/00813

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	4255081	NONE					
US	4641498	NONE					
US	5676522	CA	2165863	EP	719906	FR	2728618
		JP	8232603				
US	4201512	DE	2836864	GB	2003236	JP	54064203
US	4534699	NONE					
US	5361587	NONE					
US	5929372	BR	9706581	EP	836751	FR	2747238
		NO	975587	WO	9738451		

END OF ANNEX